Interpreting VRAP Water Quality Parameters

VRAP volunteers monitor baseline water quality parameters: dissolved oxygen, pH, specific conductance, turbidity, and water temperature. Some volunteers also collect water samples for chlorophyll-a, bacteria, metals, total kjeldahl nitrogen, and total phosphorus analysis. These chemical and physical water quality parameters and an abbreviated summary of the applicable New Hampshire Surface Water Quality Regulations are given below.

Chemical Parameters

Dissolved Oxygen (DO)

Unit of Measurement: concentration (milligrams per liter) and saturation (percent); (abbreviated as mg/L and %, respectively).

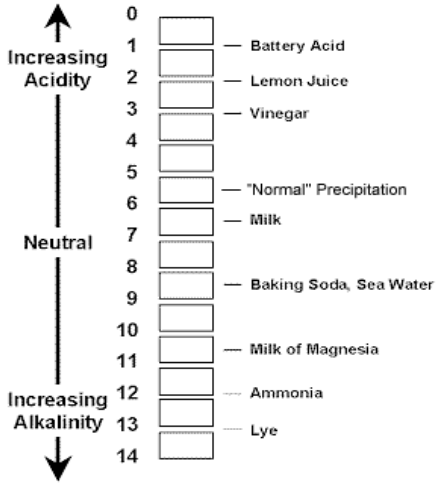
Description: A measure of the amount of oxygen in the water: Concentration is a measure of the amount of oxygen in a volume of water; saturation is a measurement of the amount of oxygen in the water compared to the amount of oxygen the water can actually hold at full saturation. Both of these measurements are necessary to accurately determine whether New Hampshire surface water quality standards are met.

Importance: Oxygen is dissolved into the water from the atmosphere, aided by wind and wave action or from rocky, steep, or uneven stream beds. Aquatic plants and algae produce oxygen in the water during the day, but consume oxygen during the night. Bacteria utilize oxygen (day and night) as they process organic matter deposited in the river into smaller and smaller particles.

- **Class A NH Surface Water Quality Standard:** 6 mg/L at any place or time, or 75% minimum daily average – (unless naturally occurring).
- **Class B NH Surface Water Quality Standard:** 5 mg/L at any place or time or 75% minimum daily average – (unless naturally occurring).

Several measurements of oxygen saturation taken in a 24-hour period must be averaged to compare to the 75 percent daily average saturation standard. The concentration of dissolved oxygen is dependent on many factors including temperature and sunlight, and tends to fluctuate throughout the day. Saturation values are averaged because a reading taken in the morning may be low due to respiration, while a measurement that afternoon may show that the saturation has recovered to acceptable levels. Water can become saturated with more than 100 percent dissolved oxygen.

pH



Unit of Measurement: units (no abbreviation)

Description: A measure of hydrogen ion activity in water, or, in general terms, the acidity of water. pH is measured on a logarithmic scale of 0 to 14 with 7 being neutral. A high pH is indicative of an alkaline or basic environment and a low pH is indicative of an acidic environment. pH is influenced by geology and soils, organic acids (decaying leaves and other matter), and human-induced acids from acid rain (which typically has a pH of 3.5 to 5.5).

Importance: pH affects many chemical and biological processes in the water and this is important to the survival and reproduction of fish and other aquatic life. Different organisms flourish within different ranges of pH. The largest variety of aquatic animals prefer a range of 6.5 – 8.0. pH outside this range reduces the diversity in the stream because it stresses the physiological systems of most organisms and can limit growth and reproduction.

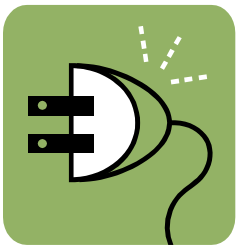
Low pH can also allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals. This can produce conditions that are toxic to aquatic life. Changes in acidity can be caused by atmospheric deposition (acid rain), surrounding rock, and certain wastewater discharges.

- **Class A NH Surface Water Quality Standard:** Between 6.5 and 8.0 (unless naturally occurring).
- **Class B NH Surface Water Quality Standard:** Between 6.5 and 8.0 (unless naturally occurring).

Sometimes, readings that fall below this range are determined to be naturally occurring, perhaps because of the influence of wetlands near the sample station. This is due to the presence or release of tannic and humic acids by decaying plants, which can create more acidic waters in areas influenced by wetlands.

pH (Units)	Category
<5.0	High Impact
5.0 – 5.9	Moderate to High Impact
6.0 – 6.4	Normal; Low Impact
6.5 – 8.0	Normal;
6.1 – 8.0	Satisfactory

Conductivity or Specific Conductance (Cond. or SpCond)



Unit of Measurement: micromhos per centimeter or microsiemens per centimeter (abbreviated as umhos/cm or uS/cm, respectively.

Description: The numerical expression of the ability of water to carry an electrical current at 25° C, and is a measurement of free ion (charged particles) content in the water. These ions can come from natural sources such as bedrock, or human sources such as stormwater runoff. Specific conductance can be used to indicate the presence of chlorides, nitrates, sulfates, phosphates, sodium, magnesium, calcium, iron, and aluminum ions. The difference between conductivity and specific conductance is specific conductance accounts for the actual water temperature rather than 25° C. The term "specific conductance" is used in the VRAP because the actual measurement is of the *conductivity* (or electric current) at a *specific* water temperature. In some studies and programs, the term "conductivity" is used. This term should only be used when the measurement *does not* adjust to a specific temperature.

Importance: Conductivity in streams and rivers is affected primarily by the geology of the area through which the water flows. Streams that run through areas with granite bedrock tend to have lower conductivity because granite is composed of more inert materials that do not ionize (dissolve into ionic components) when washed into the water. On the other hand, streams that run through areas with clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water. Groundwater inflows can have the same effects depending on the bedrock they flow through.

Discharges to streams can change the conductivity depending on their make-up. Specific conductance readings are useful in locating potential pollution sources because they usually have higher specific conductance than unimpaired surface waters. High specific conductance values may indicate pollution from sources such as road salting, septic systems, wastewater treatment plants, or urban/agricultural runoff.

- **Class A NH Surface Water Quality Standard:** No numeric standard.
- **Class B NH Surface Water Quality Standard:** No numeric standard.

There is no standard for specific conductance, because levels naturally vary a great deal according to the geology of an area. Mountain streams typically have low conductivity and freshwater coastal streams typically have high conductivity.

Unit	Category
0 – 100	Normal
101 – 200	Low Impact
201 – 500	Moderate Impact
> 501	High Impact

Turbidity

Unit of Measurement: Nephelometric Turbidity Units (abbreviated at NTU)

Description: A measurement of the amount of suspended material in the water, such as clay, silt, algae, suspended sediment, and decaying plant material.

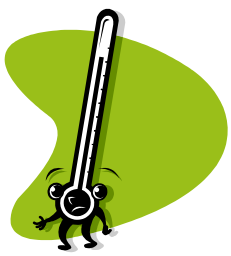
Importance: Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates. Clean waters are generally associated with low turbidity, but there is a high degree of natural variability involved. Rain events often contribute turbidity to surface waters by flushing sediment, organic matter and other materials from the surrounding landscape into surface waters. Sources of turbidity include soil erosion, waste discharge, urban runoff, and excessive algal growth.

- **Class A NH Surface Water Quality Standard:** As naturally occurs.
- **Class B NH Surface Water Quality Standard:** Shall not exceed naturally occurring conditions by more than 10 NTU.

Physical Parameters

Temperature

Unit of Measurement: °Celsius



Importance: Temperature is one of the most important and commonly observed water quality parameters. Temperature influences the rate of many physical, chemical and biological processes in the aquatic environment. Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health. Optimal temperatures for fish depend on the species: some survive best in colder water; others survive best in warmer water. Benthic macroinvertebrates are also sensitive to temperature and will move in the stream to find their optimal temperature. If temperatures are outside this optimal range for a prolonged period of time, organisms are stressed and can die.

For fish, there are two kinds of limiting temperatures – the maximum temperature for short exposures and a weekly average temperature that varies according to the time of year and the life cycle stage of the fish species. Reproductive stages are the most sensitive stages.

Temperature also affects the oxygen content of the water (oxygen levels become lower as temperature increases); the rate of photosynthesis by aquatic plants; the metabolic rats of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites, and diseases.

Causes of temperature change include weather, removal of shading streambank vegetation, impoundments (a body of water confined by a barrier such as a dam), discharge of cooling water, urban storm water, and groundwater inflows to the stream.

- **Class A NH Surface Water Quality Standard:** No numeric standard; as naturally occurs.
- **Class B NH Surface Water Quality Standard:** Temperature in Class B waters (waters that are clean enough to safely swim and fish) shall be in accordance with RSA 485-A:8, II which states in part "any stream temperature increase associated with the discharge of treated sewage, waste or cooling water, water diversions, or releases shall not be such as to appreciably interfere with the uses assigned to this class."

Nutrient Parameters

Chlorophyll-a (*Chlor a*)

Unit of Measurement: Milligrams per liter (abbreviated as mg/L)

Description: An estimate of the biomass of planktonic algae in the river. The technical term "biomass" is used to represent "amount by weight." Chlorophyll-a can be strongly influenced by phosphorus, which is derived by natural and human activities.

Importance: Because algae is a plant and contains chlorophyll-a, the concentration of chlorophyll-a found in the water gives an estimation of the concentration of algae.

- **Class A NH Surface Water Quality Standard:** No numeric standard.
- **Class B NH Surface Water Quality Standard:** No numeric standard.

Unit	Category
< 3	Excellent
3 – 7	Good
7 – 15	Less than desirable
> 15	Nuisance

Total Phosphorus (TP)

Unit of Measurement: Milligrams per liter (abbreviated as mg/L)

Description: A measure of all forms of phosphorus in the water, including inorganic and organic forms. There are many sources of phosphorus, both natural and human. These include soil and rocks, sewage, animal manure, fertilizer, erosion, and other types of contamination.

Importance: Phosphorus is a nutrient that is essential to plants and animals, however, in excess amounts can cause rapid increases in the biological activity in water. Phosphorus is usually the "limiting nutrient" in freshwater streams, which means relatively small amounts can increase the amount of algae and chlorophyll-a levels in the river. It can also decrease oxygen levels and the attractiveness of waters for recreational purposes. Phosphorus can indicate the presence of sewage, animal waste, fertilizer, erosion, or other types of pollution.

- **Class A NH Surface Water Quality Standard:** No numeric standard; as naturally occurs.
- **Class B NH Surface Water Quality Standard:** No numeric standard; unless naturally occurring, shall contain no phosphorus in such concentrations that would impair any existing or designated uses.

Unit	Category
< 0.010	Ideal
0.011 – 0.025	Average
0.026 – 0.050	More than desirable
> 0.051	Excessive (potential nuisance concentration)

Total Kjeldahl Nitrogen (TKN)

Unit of Measurement: Milligrams per liter (abbreviated mg/L)

Description: A measure of the amount of ammonia and organic nitrogen in the water.

Importance: High nitrogen can increase the amount of algae and chlorophyll-a levels in the river, but is generally of less concern in fresh water when compared to phosphorus. Nitrogen can indicate the presence of sewage, animal waste, fertilizer, erosion, or other types of pollution.

- **Class A NH Surface Water Quality Standard:** No numeric standard; as naturally occurs.
- **Class B NH Surface Water Quality Standard:** No numeric standard, unless naturally occurring, shall contain no nitrogen in such concentrations that would impair any existing or designated uses.

Unit	Category
< 0.25	Ideal
0.26 – 0.40	Average
0.41 – 0.50	More than desirable
> 0.51	Excessive (potential nuisance concentration)

Other Parameters

Chloride

Unit of Measurement: Milligrams per liter (abbreviated as mg/L)

Description: The chloride ion (Cl-) is found naturally in some surface waters and groundwater and in high concentrations in seawater. Higher-than-normal chloride concentrations in freshwater, due to sodium chloride (table salt) that is used on foods and present in body wastes, can indicate sewage pollution. The use of highway deicing salts can also introduce chlorides to surface water or ground water. Elevated groundwater chlorides in drinking water wells near coastlines may indicate saltwater intrusion.

In New Hampshire, the application of road salt for winter accident prevention is a large source of chloride to the environment, which is increasing over time due to the expansion of road networks and increased vehicle traffic. Road salt (most often sodium chloride) readily dissolves and enters aquatic environments in ionic forms. Although chloride can originate from natural sources, most of the chloride that enters the environment is associated with the storage and application of road salt. As such, chloride-containing compounds commonly enter surface water, soil, and groundwater during late-spring snowmelt (since the ground is frozen during much of the late winter and early spring). Chloride ions are conservative, which means they are not degraded in the environment and tend to remain in solution, once dissolved. Chloride ions that enter ground water can ultimately be expected to reach surface water and, therefore, influence aquatic environments and humans.

Importance: Research shows that elevated chloride levels can be toxic to freshwater aquatic life. Among the species tested, freshwater aquatic plants and invertebrates tend to be the most sensitive to chloride. In order to protect freshwater aquatic life in New Hampshire, the state has adopted acute and chronic chloride criteria.

- **Acute Standard:** Acute toxicity means an adverse effect such as mortality or debilitation caused by an exposure of 96 hours or less to a toxic substance (i.e.; short period of time). The acute standard is 860 mg/L.
- **Chronic Standard:** Chronic toxicity means an adverse effect such as reduced reproductive success or growth, or poor survival of sensitive life stages, which occurs as a result of prolonged exposure to a toxic substance (i.e.; long period of time). The chronic standard is 230 mg/L.

Escherichia Coliform Bacteria (E. coli)

Unit of Measurement: Counts per 100 milliliter (abbreviated as cts/100 mL)

Description: An indicator of the potential presence of pathogens in fresh water. E. coli bacteria is a normal component in the large intestines of humans and other warm-blooded animals, and can be excreted in their fecal material. Organisms causing infections or disease (pathogens) are often excreted in the fecal material of humans and other warm-blooded animals.

Importance: E.coli bacteria is a good indicator of fecal pollution and the possible presence of pathogenic organisms. In freshwater, E. coli concentrations help determine if the water is safe for recreational uses such as swimming. In addition to the possible health risk associated with the presence of elevated levels of E. coli, they can also cause cloudy water, unpleasant odors, and an increased oxygen demand.

- **Class A NH Surface Water Quality Standard:** Unless naturally occurring, shall contain not more than either a geometric mean of 47 E. coli cts/100 mL based on at least three samples obtained over a sixty-day period, or greater than 153 E. coli cts/100 mL in any one sample.
- **Class B NH Surface Water Quality Standard:** Unless naturally occurring, shall contain not more than either a geometric mean of 126 E. coli cts/100 mL based on at least three samples obtained over a sixty-day period, or greater than 406 E. coli cts/100 mL in any one sample.

Metals

Depending on the metal concentration, its form (dissolved or particulate), and the hardness of the water, trace metals can be toxic to aquatic life. Metals in dissolved form are generally more toxic than metals in the particulate form. The dissolved metal concentration is dependent on the pH of the water, as well as the presence of solids and organic matter that can bind with the metal to render it less toxic.

Hardness is primarily a measure of the calcium and magnesium ion concentrations in water, expressed as calcium carbonate. The hardness concentration affects the toxicity of certain metals. New Hampshire water quality regulations include numeric criteria for a variety of metals. Since dissolved metals are typically found in extremely low concentrations, the potential contamination of samples collected for trace metals analyses has become a primary concern of water quality managers. To prevent such contamination and to ensure reliable results, the use of "clean techniques" is becoming more and more frequent when sampling for dissolved metals. Because of this, sampling for metals may be more costly and require additional effort than in the past.

New Hampshire Volunteer River Assessment Program

NH Department of Environmental Services
29 Hazen Drive – PO Box 95
Concord NH 03301
p (603) 271-2963 – f (603) 271-7894
www.des.nh.gov/wmb/vrap

2006